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# Role of Chest X-ray in Assessing Severity of Pneumonia in Children Aged 3 to 59 Months

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## Abstract

**Background**: Pneumonia is a leading cause of morbidity and mortality among children aged 3 to 59 months globally. Chest X-ray (CXR) remains a common diagnostic tool, but its utility in assessing severity and guiding clinical management in pediatric pneumonia needs further clarification.

**Objective**: To evaluate the role of chest X-ray findings in determining the severity of pneumonia in children aged 3 to 59 months and correlate radiographic findings with clinical outcomes.

**Methods**: This hospital-based observational study included 150 children aged between 3 and 59 months diagnosed clinically with pneumonia. All children underwent chest X-rays upon admission. Radiographic findings were classified according to WHO standardized interpretation criteria. Clinical severity was assessed based on WHO clinical severity classification. Correlations between radiological findings, clinical severity, and outcomes were analyzed.

**Results**: Radiographic abnormalities were identified in 78% of cases. Consolidation was significantly associated with severe pneumonia ($p < 0.001$) and increased need for supplemental oxygen and longer hospital stays. Normal or minimal radiographic findings correlated with milder clinical presentations and shorter hospitalizations.

**Conclusion**: Chest X-ray remains an effective adjunct tool for assessing pneumonia severity in young children. Radiographic findings correlate closely with clinical severity and can assist in early decision-making regarding the intensity of treatment and management strategies.

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## Introduction

Pneumonia remains one of the leading causes of morbidity and mortality globally among children under five years, particularly in low- and middle-income countries. According to the World Health Organization (WHO), pneumonia accounts for approximately 14% of all deaths in children under five, highlighting its significance as a public health concern, especially in resource-limited settings (1). In India alone, pneumonia contributes substantially to under-five mortality, despite advances in diagnosis and treatment strategies (2).

Accurate assessment of pneumonia severity is crucial to guide appropriate clinical management, including the timely initiation of antibiotics, hospitalization decisions, and supportive care. Traditionally, clinical parameters such as respiratory rate, presence of chest indrawing, oxygen saturation, and altered sensorium are employed to classify pneumonia severity based on WHO guidelines (3). However, clinical assessment alone has limitations, such as interobserver variability and subjective judgment, making it challenging to precisely gauge disease severity and the need for intensive interventions.

Chest X-ray (CXR) imaging has long been used as an adjunct diagnostic modality in evaluating respiratory illnesses, including pneumonia. Radiographic findings such as consolidation, alveolar infiltrates, pleural effusions, and interstitial infiltrates can provide objective evidence of lung involvement, potentially aiding clinicians in stratifying disease severity (4). While several guidelines advocate the use of chest radiography primarily to confirm complicated pneumonia or identify complications such as effusions and empyema, its role in routine severity assessment and initial management decisions remains controversial.

The WHO developed standardized criteria for interpreting pediatric chest radiographs in pneumonia, aiming to improve diagnostic consistency across settings (5). Radiographic pneumonia is defined primarily by alveolar consolidation and/or pleural effusion, while other nonspecific changes, such as interstitial infiltrates, are considered less definitive for pneumonia. Studies evaluating WHO radiographic criteria report varying sensitivity and specificity, underscoring the need to clarify how radiographic findings correspond to clinical severity and outcomes in pediatric pneumonia (6).

Previous research exploring the utility of chest radiography in pediatric pneumonia severity assessment has yielded mixed results. A systematic review indicated that radiographic abnormalities, particularly consolidation, are associated with severe clinical presentations,

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prolonged hospital stays, and higher mortality risks (7). Conversely, some studies found poor correlation between radiographic findings and clinical severity, suggesting limited added value of routine CXR in uncomplicated pneumonia cases (8). These contrasting findings emphasize the need for further investigation into the clinical relevance and utility of chest X-ray in pediatric pneumonia management.

In resource-limited settings, the decision to perform chest radiography must also consider costs, radiation exposure, and availability of radiological expertise. Therefore, identifying scenarios where chest radiographs significantly impact clinical decision-making and patient outcomes is essential. Clarifying the relationship between chest radiographic findings and clinical severity could optimize resource utilization and improve patient management, particularly in settings where radiographic facilities may be limited.

The present study aimed to address this knowledge gap by systematically evaluating the correlation between chest X-ray findings, clinical severity, and outcomes among children aged 3 to 59 months diagnosed with pneumonia. By analyzing the association between radiographic abnormalities and clinical parameters such as oxygen requirement, length of hospital stay, and complications, the study sought to clarify the clinical utility of chest X-ray imaging in the routine assessment and management of pediatric pneumonia cases.

## Methods

This hospital-based observational study was conducted in the pediatric department of a tertiary care hospital over a 12-month period, from January 2024 to December 2024. The study aimed to evaluate the role of chest X-ray (CXR) findings in determining the severity of pneumonia among children aged between 3 to 59 months.

Children within the specified age group who presented to the pediatric emergency or outpatient department and were clinically diagnosed with pneumonia based on World Health Organization (WHO) criteria were included. Clinical diagnosis of pneumonia was defined by the presence of cough or difficult breathing with fast breathing or chest indrawing, as recommended by WHO guidelines. Exclusion criteria included children with known underlying chronic respiratory diseases (e.g., bronchial asthma, cystic fibrosis), congenital heart disease, immunodeficiency conditions, and those who had received antibiotics prior to presentation.

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After obtaining informed consent from the parents or guardians, a detailed clinical history and physical examination were performed by trained pediatricians. Clinical severity was categorized based on WHO guidelines as mild (fast breathing without danger signs), moderate (chest indrawing without danger signs), or severe (presence of danger signs such as cyanosis, inability to feed, altered consciousness, or respiratory distress requiring supplemental oxygen or intensive care).

All enrolled children underwent chest X-ray examination within 24 hours of admission. Radiographs were taken in the posteroanterior (PA) view with children in the upright or supine position, based on the child's age and clinical condition. Radiographs were interpreted by an experienced pediatric radiologist who was blinded to the clinical severity. Chest X-ray findings were classified according to standardized WHO radiological criteria into three categories: (1) Normal or no significant abnormality; (2) Significant consolidation or alveolar infiltrates; and (3) Other infiltrates or interstitial changes.

Clinical outcomes documented included the requirement of supplemental oxygen therapy, admission to the pediatric intensive care unit (PICU), length of hospital stay, development of complications (e.g., empyema, pleural effusion, sepsis), and overall clinical recovery or mortality.

Data were systematically collected using a pre-structured proforma designed for the study. Variables collected included demographic data (age, gender, socioeconomic status), clinical presentation (symptoms, respiratory rate, oxygen saturation), severity categorization, radiographic findings, treatment provided, clinical outcomes, and duration of hospitalization.

Statistical analysis was performed using SPSS software (version 26.0). Categorical variables were presented as frequencies and percentages, and continuous variables as means ± standard deviations. Chi-square or Fisher’s exact tests were used to analyze associations between radiological findings and clinical severity categories. Independent t-tests or ANOVA were used to compare continuous variables like duration of hospital stay across radiographic categories. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of radiographic findings in predicting severe pneumonia were calculated. A p-value of less than 0.05 was considered statistically significant.

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The study protocol was reviewed and approved by the Institutional Ethics Committee. The principles of confidentiality and voluntary participation were strictly adhered to throughout the study.

## Results

A total of 150 children aged 3 to 59 months diagnosed with pneumonia were included. The mean age was 18.5 ± 12.8 months, with a male-to-female ratio of 1.3:1. Based on WHO clinical criteria, pneumonia was classified as mild in 46 (30.7%), moderate in 64 (42.7%), and severe in 40 (26.6%) children.

**Table 1: Demographic and Clinical Characteristics**

| Parameter | Mild (n=46) | Moderate (n=64) | Severe (n=40) | p-value |
|---|---|---|---|---|
| Mean age (months) | 16.7 ± 10.1 | 17.9 ± 11.8 | 22.3 ± 14.2 | 0.09 |
| Male : Female | 26 : 20 | 37 : 27 | 23 : 17 | 0.96 |
| Mean respiratory rate (breaths/min) | 46 ± 4 | 52 ± 5 | 62 ± 8 | <0.001 |
| Mean $SpO_2$ (%) | 96.5 ± 1.2 | 92.8 ± 2.6 | 87.2 ± 4.9 | <0.001 |

Severe pneumonia was associated with significantly higher respiratory rates and lower oxygen saturation levels compared to mild and moderate pneumonia.

**Table 2: Chest X-ray Findings According to Clinical Severity**

| Radiographic Findings | Mild (n=46) | Moderate (n=64) | Severe (n=40) | p-value |
|---|---|---|---|---|
| Normal | 17 (36.9%) | 11 (17.2%) | 5 (12.5%) | 0.01 |

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| | | | | |
|---|---|---|---|---|
| Consolidation/Alveolar infiltrates | 12 (26.1%) | 38 (59.4%) | 30 (75.0%) | <0.001 |
| Interstitial infiltrates/Others | 17 (36.9%) | 15 (23.4%) | 5 (12.5%) | 0.02 |

Consolidation was significantly more prevalent in severe pneumonia cases, while normal or minimal findings were more common in mild cases.

**Table 3: Clinical Outcomes by Chest X-ray Findings**

| **Clinical Outcome** | **Normal (n=33)** | **Consolidation (n=80)** | **Interstitial (n=37)** | **p-value** |
|---|---|---|---|---|
| Supplemental $O_2$ required (%) | 2 (6.1%) | 44 (55.0%) | 8 (21.6%) | <0.001 |
| ICU Admission (%) | 0 (0%) | 19 (23.8%) | 3 (8.1%) | 0.004 |
| Complications (%) | 1 (3.0%) | 12 (15.0%) | 3 (8.1%) | 0.12 |

Children with consolidation had significantly higher rates of supplemental oxygen requirement and ICU admissions.

**Table 4: Hospital Stay Duration by Radiographic Findings**

| **Radiographic Finding** | **Mean Hospital Stay (days)** | **p-value** |
|---|---|---|
| Normal | 3.2 ± 1.1 | |
| Consolidation | 6.8 ± 2.3 | <0.001 |
| Interstitial infiltrates | 4.9 ± 1.5 | |

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Children with consolidation had significantly longer hospital stays compared to other radiographic findings.

**Table 5: Diagnostic Accuracy of CXR Findings for Severe Pneumonia**

| Radiographic Feature | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) |
|---|---|---|---|---|
| Consolidation | 75.0 | 63.6 | 37.5 | 89.1 |
| Interstitial infiltrates | 12.5 | 73.6 | 13.5 | 72.9 |
| Normal CXR | 12.5 | 72.7 | 15.2 | 68.9 |

Consolidation on chest X-ray was the most sensitive indicator for severe pneumonia, providing substantial negative predictive value for severity assessment.

## Discussion

This observational study assessed the role of chest X-ray (CXR) in determining the severity of pneumonia among children aged 3 to 59 months. Our findings demonstrate a significant correlation between radiographic findings and clinical severity, reinforcing the utility of chest radiography as an adjunctive tool in the management of pediatric pneumonia.

In our study, consolidation or alveolar infiltrates were the predominant radiographic abnormalities and were strongly associated with severe pneumonia. This aligns with previous studies that identified alveolar consolidation as a critical radiographic feature indicating bacterial pneumonia and a predictor of severe clinical outcomes, including higher oxygen requirements and prolonged hospital stays (5,7). Similarly, another study reported that alveolar consolidation had the highest inter-observer agreement among radiologists, further supporting its clinical reliability as an indicator of severe disease (6).

Children with normal or minimal radiographic findings predominantly presented with milder clinical symptoms and significantly better outcomes, including shorter hospitalization and reduced supplemental oxygen needs. This observation echoes findings from Lynch et al., who suggested that the absence of radiographic abnormalities generally indicates less severe or

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viral-associated pneumonia, typically managed conservatively without extensive interventions (4). Hence, the absence of consolidation on chest X-ray can confidently predict a less severe clinical trajectory, potentially reducing unnecessary hospital admissions and antibiotic use.

The association between radiographic findings and clinical outcomes was particularly evident regarding hospitalization duration and intensive care unit (ICU) admissions. Our study showed that patients with consolidation had significantly longer hospital stays (mean duration: 6.8 ± 2.3 days) and higher rates of ICU admissions (23.8%) compared to those with other radiographic findings. Similar observations were reported in a multicenter study, which demonstrated that pediatric patients with clear radiographic evidence of consolidation or effusion were more likely to require intensive interventions and experienced longer hospitalization periods (8). These data underscore the clinical value of early chest radiography in identifying children who may require closer monitoring and intensive management.

The diagnostic accuracy of consolidation for identifying severe pneumonia in this study (sensitivity of 75%) emphasizes its utility as a reliable marker of severe respiratory disease. Moreover, the high negative predictive value (NPV: 89.1%) indicates that a normal or minimally abnormal chest X-ray could effectively rule out severe pneumonia in young children. This diagnostic value has substantial clinical implications, especially in low-resource settings, enabling clinicians to prioritize limited resources and interventions to children most at risk. A systematic review similarly concluded that radiographic evidence of consolidation was highly predictive of severe bacterial pneumonia, highlighting the importance of routine radiographic evaluation in clinical decision-making (4).

Despite the demonstrated clinical utility, routine chest X-ray use in pediatric pneumonia remains a topic of debate, particularly considering radiation exposure risks, availability of radiology expertise, and healthcare resource constraints. WHO guidelines recommend reserving chest radiography primarily for complicated pneumonia cases or where clinical ambiguity exists (1). However, given the substantial correlation between radiographic findings and clinical severity observed in our study, selective chest radiography could significantly enhance clinical decision-making, especially in moderate-to-severe cases or in settings with diagnostic uncertainty. Such selective imaging strategies could optimize resource utilization without compromising patient care.

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Our study, however, has certain limitations. Firstly, being a single-center observational study, generalizability may be limited. Multicentric and larger-scale studies could further validate our findings across diverse geographic and healthcare settings. Secondly, inter-observer variability in interpreting chest radiographs, although minimized through standardized WHO interpretation criteria, could introduce bias. Future studies incorporating digital imaging techniques or artificial intelligence-based image analysis could reduce observer-related variability, potentially enhancing diagnostic accuracy and reliability.

Despite these limitations, the findings of this study provide robust evidence supporting the utility of chest radiography in assessing pneumonia severity in young children. Chest X-ray findings, particularly alveolar consolidation, closely correlate with clinical severity, hospitalization duration, and the need for intensive interventions, enabling clinicians to make more informed decisions in pediatric pneumonia management.

## Conclusion

Chest X-ray plays an essential role in assessing pneumonia severity among children aged 3 to 59 months. Radiographic findings, particularly consolidation, strongly correlate with severe clinical presentations, prolonged hospitalization, and increased need for intensive interventions. Incorporating chest radiography selectively into clinical management strategies can facilitate timely identification and effective treatment of severe pneumonia in pediatric populations.

## Recommendations

Routine use of chest radiography should be advocated in cases of moderate-to-severe pediatric pneumonia or clinical ambiguity to optimize treatment decisions. Healthcare settings, especially those with limited resources, should develop clear guidelines for the selective utilization of chest X-rays. Further studies should explore standardized imaging protocols and investigate innovative technologies, such as digital imaging and artificial intelligence-based diagnostic tools, to enhance diagnostic accuracy and reduce inter-observer variability.

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